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EFFECTS OF THE HERBICIDE ATRAZINE ON COLLEMBOLA

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The number and kind of Collembola constitute an index of biological activity of the soil. According to Tomlin (1975), changes in soil populations may cause problems for other pedofaunal groups, and thus much research has centered on delimiting possible non-target effects of pesticides on these Apterygota insects.

Field studies with herbicides (for review see Eijsackers and van der Drift, 1976; Edwards and Stafford, 1979) have provided contrasting results. Monuron and DNOC were found to negatively affect Collembola populations, whereas TCA seems to increase the number of individuals. Linuron, MCPA, 2,4,5-T, 2,4,5-TP, MH, tri-allate, suffix and 2,4-D have practically no effect. Dalapon can increase, decrease, or have no effect. Paraquat caused no effects in one study and a decrease in Collembola populations in another. This decrease has also been confirmed by Ischibashi et al. (1978). For the triazines, of which atrazine is a member, Edwards and Arnold (1964), Edwards (1965, 1970), Stringer et al. (1970) and Prasse (1975) found a decrease in Collembola populations in soils treated with simazine.Edwards (1970) and Edwards and Stafford (1979) found a direct negative effect following application of simazine and cyanazine. Steinbrenner et al. (1960) found nil effect of simazine. Bäumler et al. (1978) reported that simazine has a negative effect on Collembola, but only in soils containing little organic material. Conflicting results have been reported also for atrazine. Fox (1964) considered a field treated with atrazine and left uncultured; he found fewer Collembola even 14 months after treatment with about 9 kg/ha of herbicide. The author concluded that most of the effects were indirect in nature, for the most part due to the changes in soil flora. Popovici et al. (1977) subsequently studied the influence of atrazine (5 and 8 kg/ ha) on a maize field. The authors found a decrease of most of the animals investigated, including Collembola, in direct relationship with herbicide doses. These decreases were partially compensated four months after the treatment. Individual Collembola

families showed different responses. Isotomidae were more resistant to atrazine, whereas Hypogastruridae were eliminated by doses as low as 5 kg/ha and with doses of 8 kg/ha do not recover even four months after. Moore et al. (1984) and Mallow et al. (1985) studied the effects of different methods of tillage with and without atrazine and found no differences after atrazine treatment. Our research group initially investigated a maize field at Cadriano (Bologna, Italy) treated several times with atrazine on alternate years (Sabatini et al., 1979). None of the employed treatment levels (2, 4, and 6 kg/ha) was found to affect the microarthropod number, in particular that of Collembola. Successively two other fields were studied: the first again at Cadriano treated for the second year with atrazine (0, 2, 6 kg/ha) and the second at Vitulazio (Caserta) treated for the first time and with the same doses as at Cadriano (Bertolani et al., 1981; Fratello et al., 1985). The field at Cadriano did not show any effects on Acarina and Collembola populations. Instead the Vitulazio field had an initial decrease in the overall number of Collembola in the upper soil layer (0-10 cm deep), particularly at 6 kg/ha dose. Recovery is almost complete after one month. Onychiuridae are very sensitive to atrazine, since their number in both the upper and lower (10-20 cm deep) layers remains depressed even one month after treatment. Two other families demonstrate a prolonged effect of the atrazine; at the species level Willemia buddenbrocki Huether shows a decrease in number which appears later than in other Hypogastruridae; Isotomiella minor (Schaeffer) is, among Isotomidae, the only species that does not recover within 30 days from treatment. The different effects of atrazine in the various fields have been mainly attributed to different soil binding properties (Fratello et al., 1985).

We also performed laboratory tests on the effects of atrazine on Collembola to limit the number of variables and allow a closer evaluation of direct and indirect effects, lethal dose, fecundity, etc. (Mola et al., in press).

A similar experiment had already been performed by Subagja and Snider (1981) for two species of Collembola; atrazine (5,000 ppm) was mixed with brewer's yeast utilized as the food source. Mortality rates were 50% after 4 weeks for Tullbergia granulata Mills and 5% after 6 weeks for Folsomia candida (Willem). Instar duration lengthened and reduced fecundity was also found. Subagja and Snider suggested that the cause of death of T. granulata and F. candida, which occurred late, could be attributed to starvation. Atrazine thus seemed to exert its effects by making the foodstuff repellant and would no act directly on the animals themselves.

The activity of other herbicides on laboratory reared Collembola has been studied by several authors. 2,4,5-T was shown to be lethal, to cause changes in mobility and to have repellant effects on Onychiurus quadriocellatus Gisin (Eijsackers, 1975, 1978). Fecundity of T. granulata and F. candida was reduced at 5,000 ppm dosage of paraquat (Subagja and Snider, 1981). Prometryne, a triazine, linuron, and CIPC have marked lethal effects on Collembola, especially at doses of 1 and 10 mg per 100 g of soil (Sanoka-Woloszyn and Woloszyn, 1970).

We utilized two species of Onychiuridae; field studies have shown this family to be very sensitive to atrazine. At the lowest test concentration (2.5 ppm), corresponding to recommended agricultural dosages of 2 kg/ha (Tafuri, 1981), mortality in Onychiurus apuanicus Dallai is 18.7% after 30 days and 46.7% after 60 days. The two species have a different sensitivity to herbicide, especially at the heavier doses of 80 and 160 ppm. This is supported by the after 30 days LD50: 17.2 ppm for O. apuanicus and 20 ppm for Onychiurus armatus (Tullberg). At atrazine levels of 20 ppm or greater, oviposition does not occur, whereas lower doses do not seem to affect oviposition or fecundity of the newborns.

The finding in our experiments that atrazine has species-specific effects in the two species considered must be explained by genetics. Though the different binding capacities of soil have important influences on field responses, our laboratory results support that such differences must also be due to selective forces (Sabatini et al., 1979). This hypothesis has also been proposed by Joosse (1983) on the basis of the high genetic variability found in Collembola populations. The dose corresponding to 2 kg/ha, which does not cause remarkable effects in the field, is indeed lethal in our laboratory studies though it does not cause changes in fecundity.

Thus atrazine also seems to have insecticidal properties. It directly affects Collembola, one of the most important components of the pedofauna and an important link in the food chains of agricultural fields, and so indirectly also other organisms.

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